Using High Early Concrete or Accelerators

One Hot Topic

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Dave Figurski - LafargeHolcim
Tom McNamee - Master Builders Solutions

Strength in Numbers

Colorado Ready mixed concrete association

Introductions

- Dave Figurski - Tech Service Engineer, LafargeHolcim
- Tom McNamee - Mtn. Region Manager, Master Builders Solutions
- Matt McCombs - RMX Quality Manager, Martin Marietta

Strength in Numbers

Why this presentation?

- Clarify terminology
- To get municipalities, specifiers, RMX suppliers, and contractors all on same page
- To help ensure contractors receive concrete performance they need
- Realistic expectations

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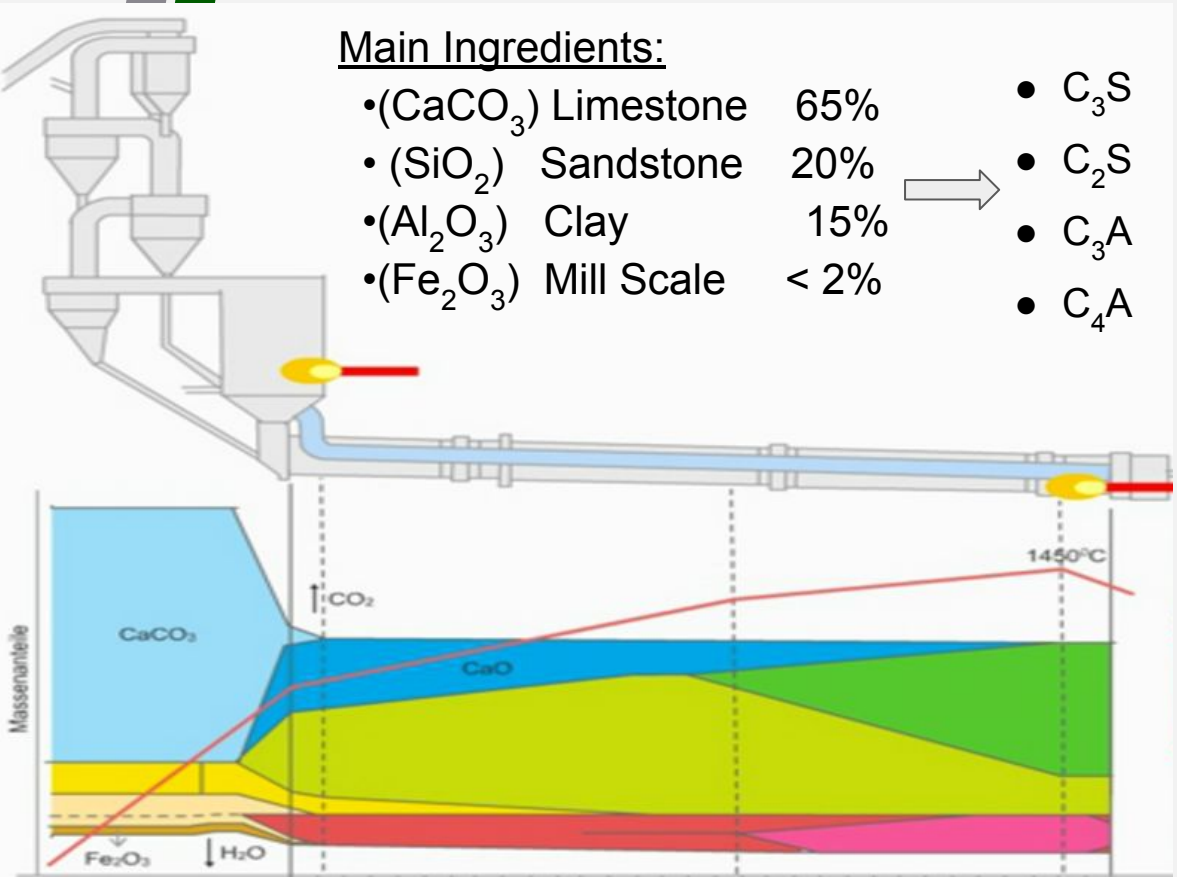
Basics of Cement Manufacturing



- Heat causes chemical changes in materials
- Changes are locked in place via rapid cooling (quenching)

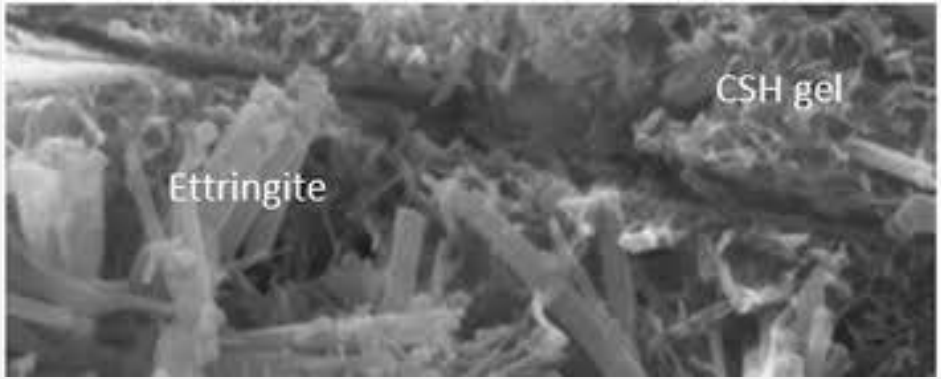
Clinker

Basics of Hydration

- Cement reacts chemically with water, creating hydration products
- C_3S - <u>early strength development</u>
    - Generates C-S-H (glue that holds concrete together)
- C_3A - Heat of Hydration & <u>Time of Set</u>
    - Dissolving in water releases heat (Heat of Hydration...exothermic)
    - This crystal growth is responsible for setting of concrete

The effectiveness in these depend on:

- Quantity
- Rate of Reaction



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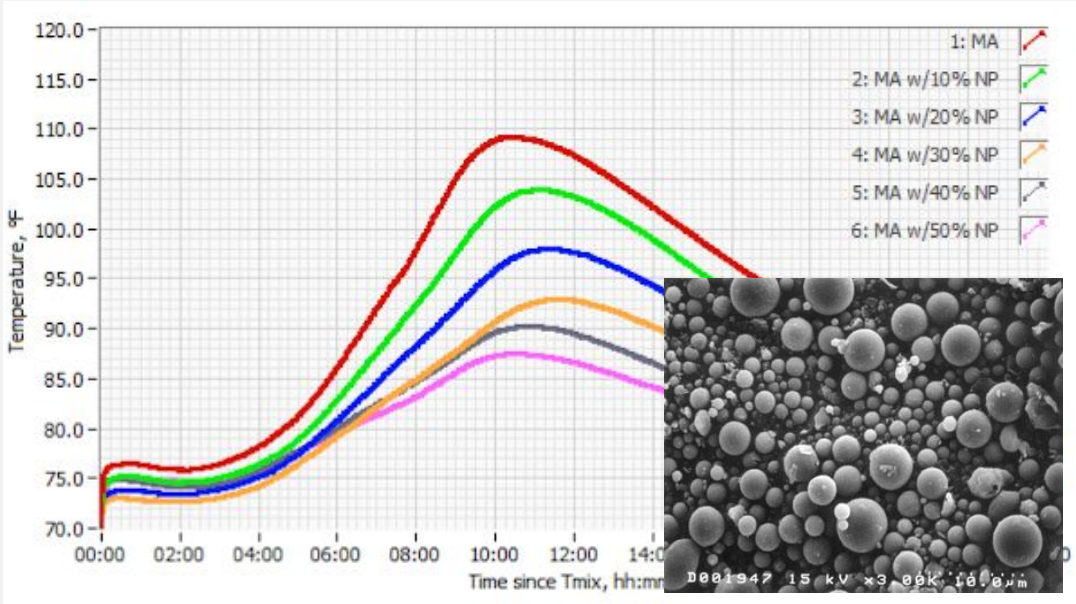
How materials affect strength gain & time of set?

- <u>Cement</u>
  - Quantity in a yard
  - Physical Properties
    - Fineness
  - Chemical Properties
    - C_3S content
    - C_3A content

- <u>SCM's</u> - fly ash, slag, natural pozzolans
  - Are not all the same...even within types
  - Typically reduce heat generation, set times, early strength
  - Generate more workable & durable concrete



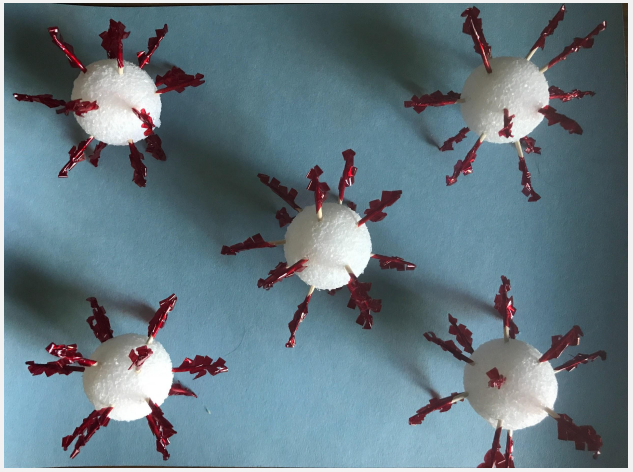
Heat generation/ conservation is critical!

Strength in Numbers

How materials affect strength gain & time of set?

- Water content simplified
  - More water = easier to work with
  - More water = less strength/less durable

- Admixtures...varies
  - Can tailor the performance of the mix
  - Increase workability with the same w/c
  - Accelerators to decrease set times or increase strength development
  - Consult ready mix with any desired changes



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How other conditions affect strength gain & time of set?

- Environment
  - Anything that reduces heat
    - Ground/ambient temps.
    - Shade
    - Frozen ground concerns
  - Infrared thermometers are handy

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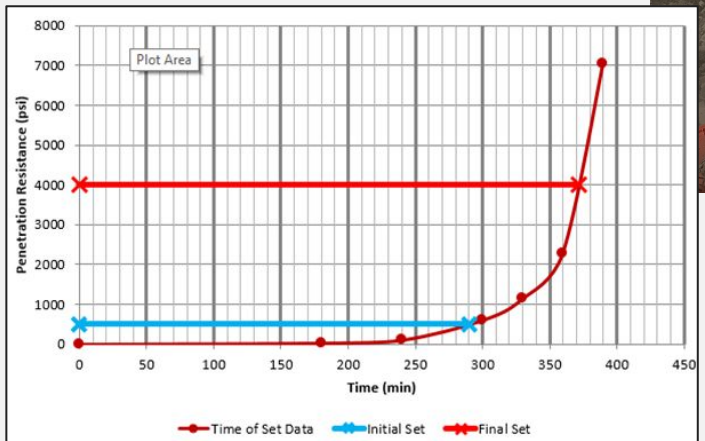
How other conditions affect strength gain & time of set?

- Cure Temperatures
  - What are you trying to accomplish??
- Hydration is temperature/time dependent
  - Maturity

	Total Cem.	750 III @ 0.40	705 @ 0.40 w/Accel	705 @ 0.45
	C150 Type III	564		
	595 IPN		705	705
	Class F Ash	141		
	3/4"	1493	1450	1450
	Sand	1250	1215	1235
	Water	278	292	318
	w/c	0.394	0.414	0.451
	s/a	0.46	0.46	0.46
	HRWR (oz/cwt)	6.0	5.4	4.4
	Accelerator (oz/cwt)	0.0	35.0	0.0
	Air	5.0%	8.0%	6.2%
	Slump (in)	8 1/4	9 3/4	8 1/4
Individual Cylinder Breaks	18hr Heat Cure (achieved 100F)	4,580	3,160	3,110
		4,800	3,320	3,160
	18hr-(50F estimated)	742	560	290
Averages	0.75	4,690	3,240	3,135
	7	8,360	7,790	6,600
	15	9,000	8,170	7,200
	28	9,163	8,443	7,530
	7-D % of 28-D	91%	92%	88%

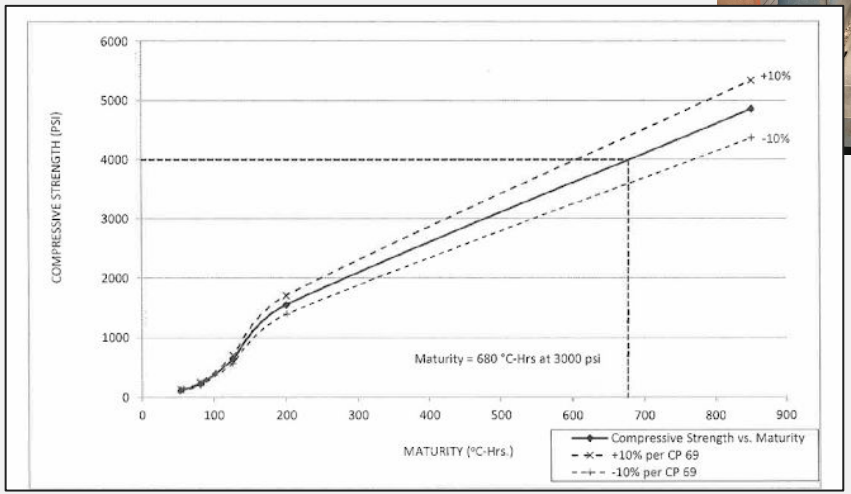
Measuring Set time (Accelerated)

- Initial/Final Set (Penetration Resistance)
  - Initial = 500 psi
  - Final = 4,000 psi
  - Not comparable to compressive strength
- Finishing In Practice
  - Support weight of finisher
  - ¼” shoe depression (15-25psi) before floating
    - Allows for mix stiffening & bleed water to cease



Measuring Strength (High Early)

- Measured in psi
- Minimum strengths req'd for opening structure
  - Opening road to traffic
  - Removal of formwork for elevated deck
- Time and Temp dependent (Maturity)



Set Times

Setting Time of Concrete at Various Temperatures

Temperature °F	Setting Time hrs.
70	6
60	8
50	11
40	14
32	Freezes

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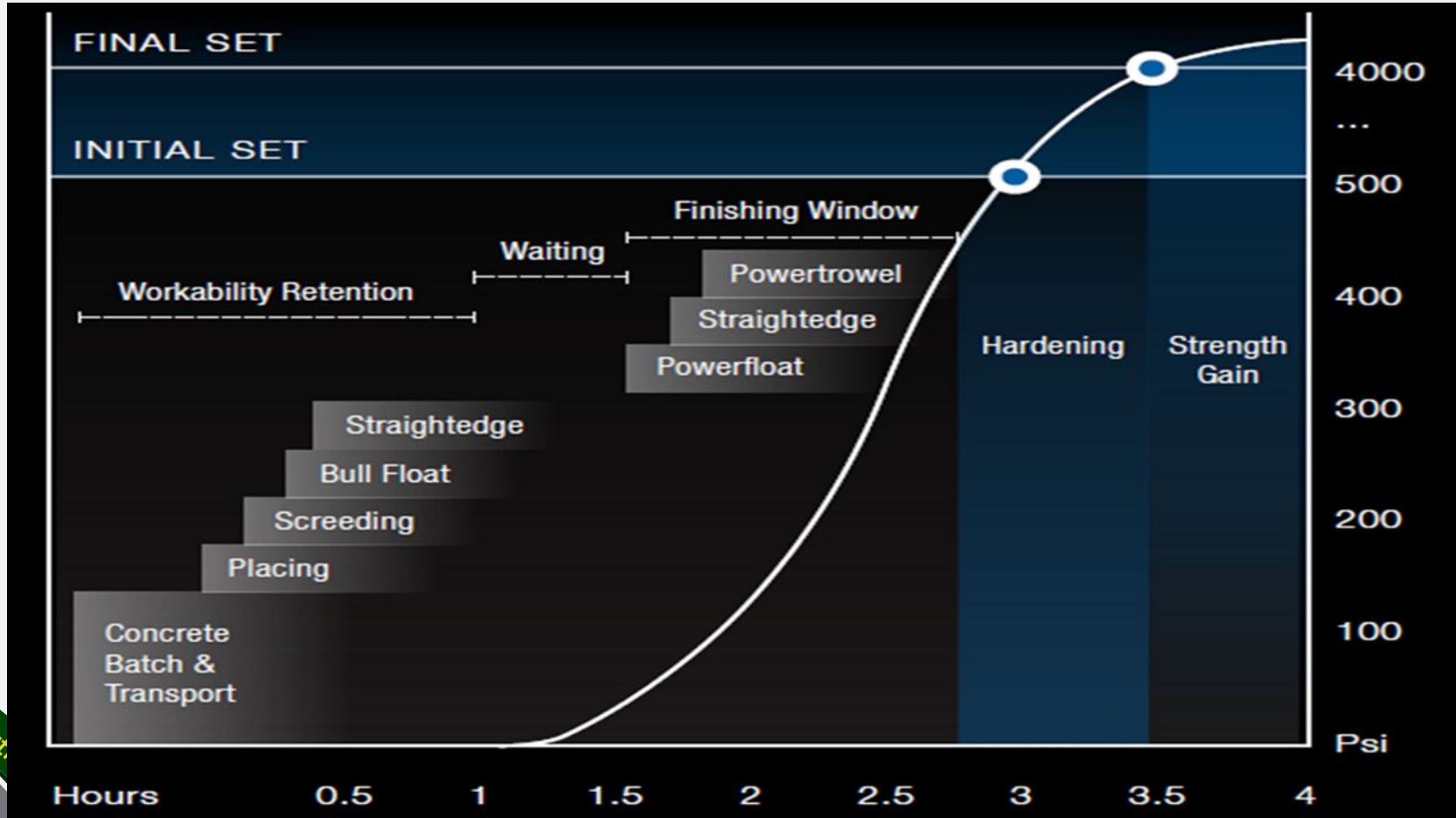
Basics of Set Time



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Accelerated Set and High Early Strength - Levers to Pull

Speed up the early hydration (heat gain) of concrete by using one or more of the following:

Additional Portland cement	Set HES
Use Type III Cement	Set HES
Hot water	Set
Heat Aggregate	Set
Calcium chloride	Set HES
Non-chloride accelerator	Set HES

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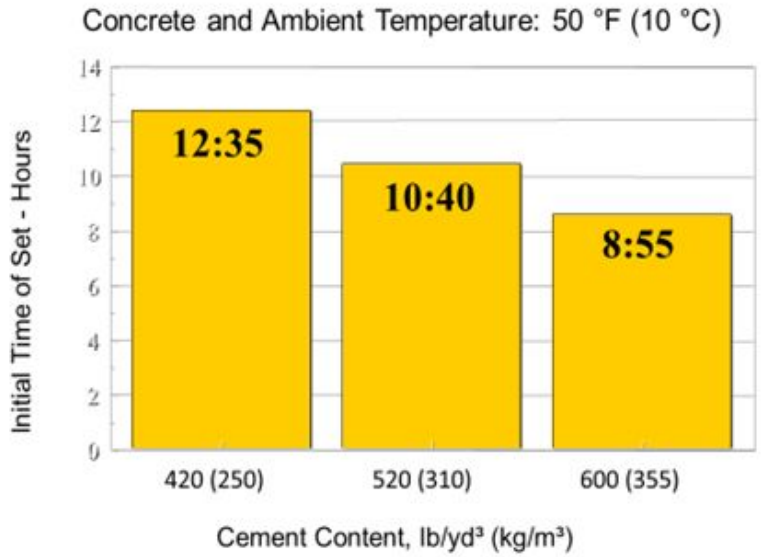
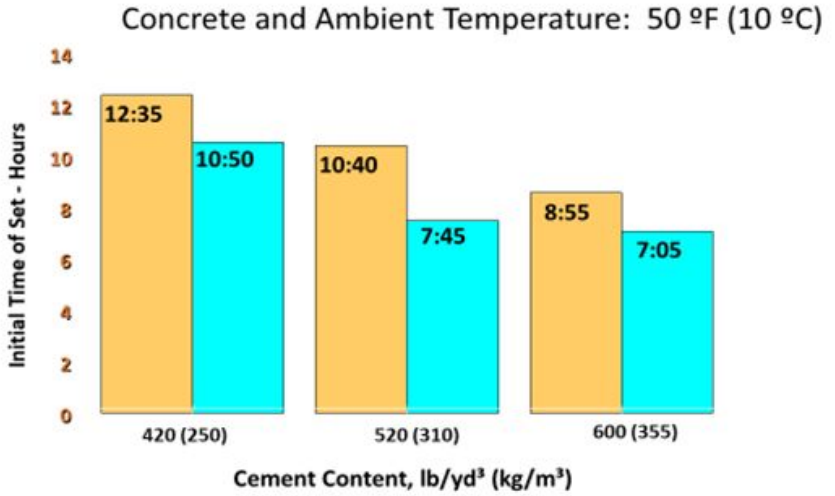
Affects on Set Time

Cement Content on Setting Time



Non-Chloride Effect Setting Time



Plain Concrete

Non-Chloride Accelerator 10oz/cwt

ACI 212.3 - Accelerating Admixtures for Concrete

- Reduce time to initial set
- Expedite the start of finishing operations
- Reduce the total time required for curing and protection
- Increase the rate of early strength development to permit earlier removal of forms and earlier opening of construction for service

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Calcium Chloride

DON’T USE WHEN REINFORCING IS IN THE CONCRETE

- Don’t use with ASR potential Aggregates
- Don’t use with high sulfate soils present
- Don’t use with colored concrete
- Don’t use over 2% by weight of cement

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Non-chloride Accelerators

- Non-Corrosive to reinforcing steel
- Accelerates setting time of concrete, allowing for faster completion of slabs
- Reduced in-place concrete costs
- Won't blotch colored concrete
- Can add more than 2% to get higher early strengths

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How contractors order accelerator?

- Typically based on % Calcium Chloride
  - What is 1%?
  - What is 2%?

- Dose of Non-Chloride Accelerator
- Amount required for Same Set Time of Calcium Chloride under Same Conditions
- Predictable Set Time is what Contractors want

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High Early Strength: Commercial Projects

Applications

Foundation Walls

Elevated Slabs

Columns

Beams

<u>Define what is required</u>:

Hardened Properties

- X Strength at Y hours
- Shrinkage
- Permeability
- Concrete temp

Plastic Properties

- Slump / Spread
- Air Entrainment

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High Early Strength: Pavement Repairs

Freeways in need of repair and rehabilitation

Contractors face $$$ fines for delays in opening freeway

Commuter impatience with lane closures !!!

High Early Strength Data with Type III Cement

Flexural Strength	psi
4-hour	480
24-hour	855
28-day	1250
Compressive Strength	
4-hour	4130
24-hour	7740
28-day	8250

Fully-loaded truck on slab
4 hours after placement !!!

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Set Time For Finishing Concrete Flatwork – Mix Design

- Cement type and performance
  - Type I/II prevalent locally (Type III is available & sets faster)
- SCM type and performance
  - Locally C Ash, F Ash and RFA
- Total cementitious and SCM replacement content
  - Straight cement reacts faster
- Water to cementitious ratio
  - Affects strength and set time
- Addition of an Accelerator
  - Calcium Chloride or Non-Calcium Chloride
- Add more cement to the base mix

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Set Time For Finishing Concrete Flatwork – Mix Design

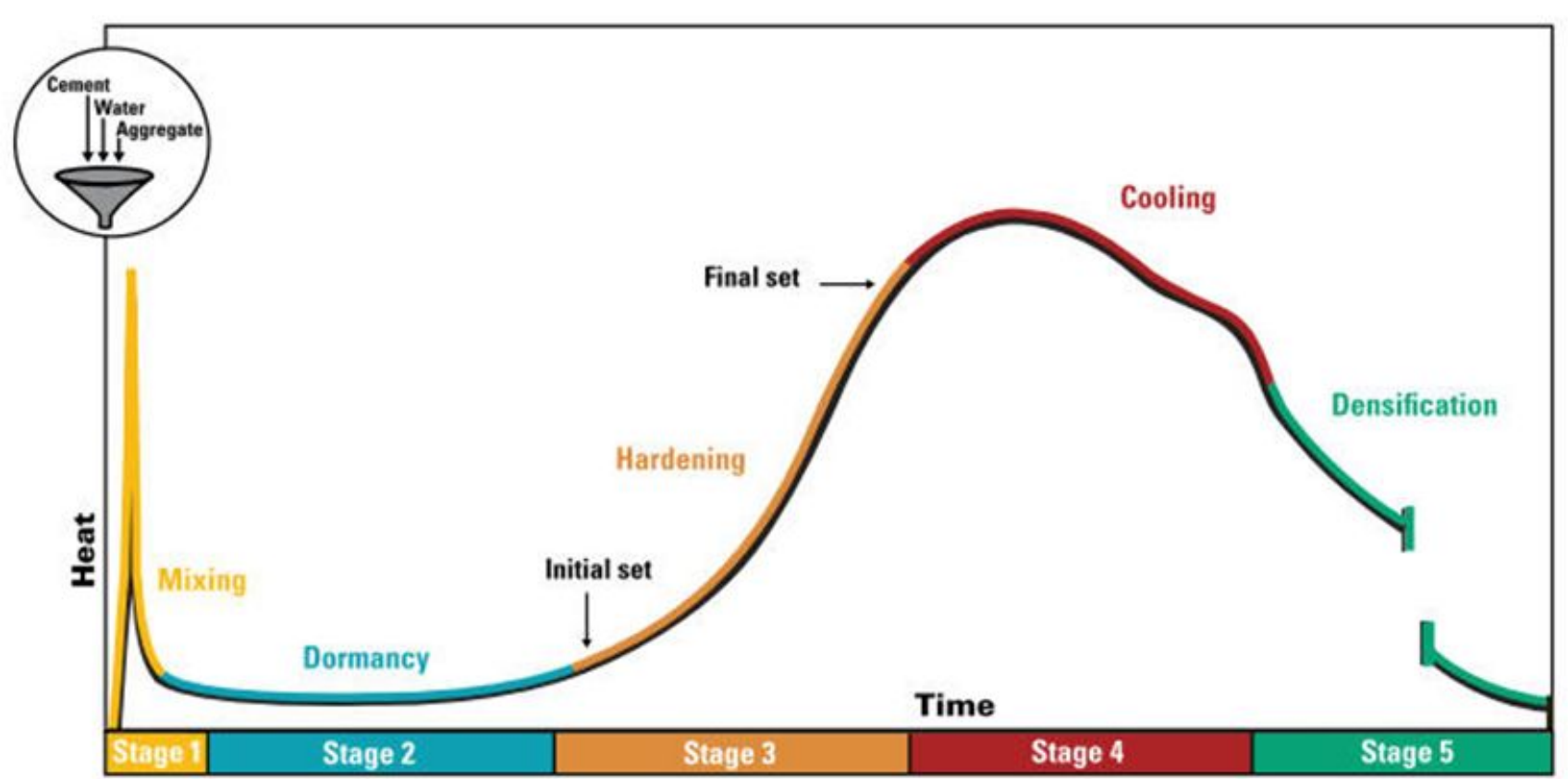
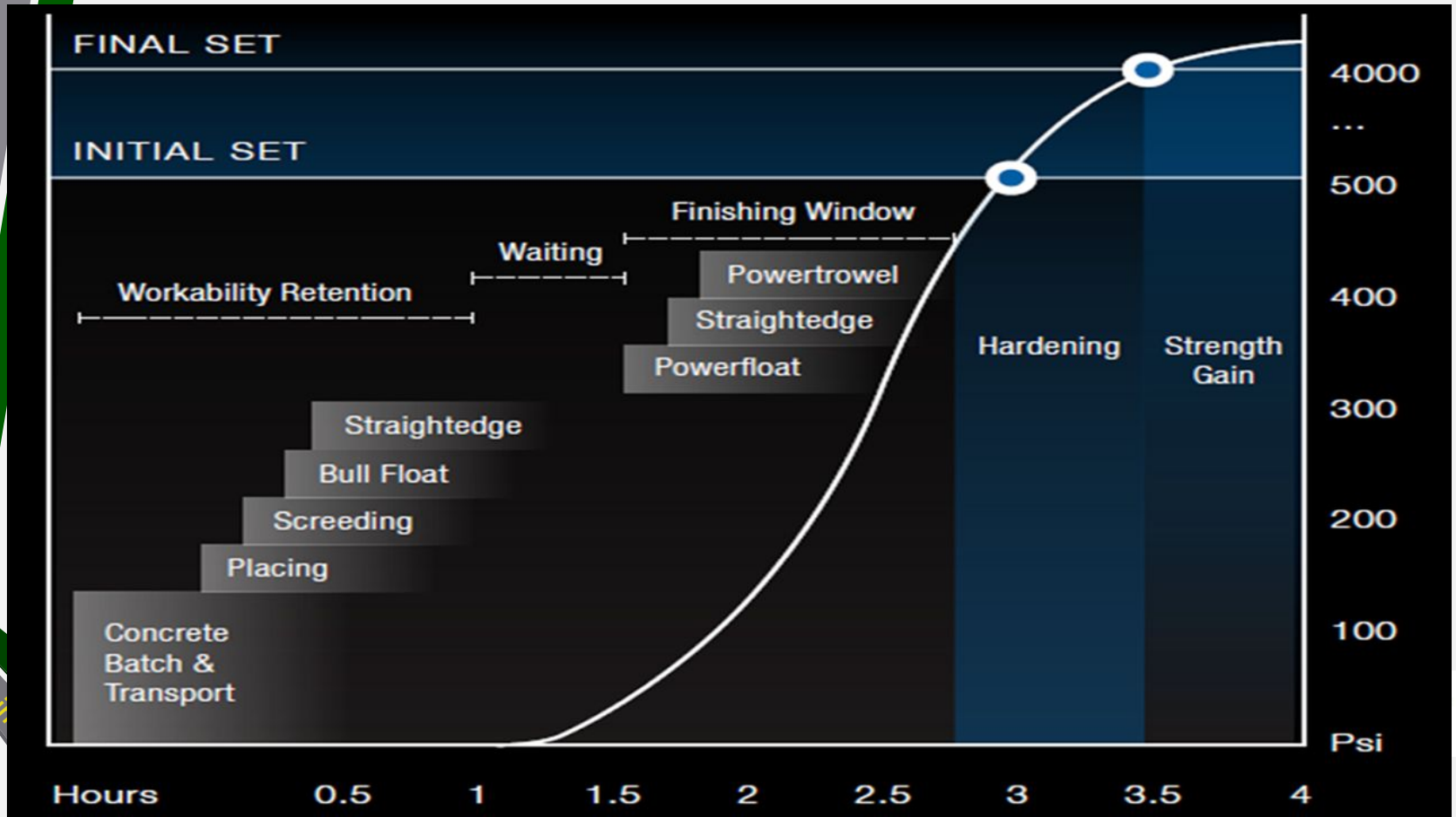


Figure 4-2. General hydration curve delineating the five stages

Set Time For Finishing Concrete Flatwork – Mix Design



Role of Temperatures & Environment on Performance

- Temperature
  - Ambient Temperature – Concrete seeks ambient temperature
  - Concrete Temperature – Strongly influenced by ambient and environmental temperature, which impacts set times and strength gain
- Environment
  - Cold ground, forms, pumps and reinforcement
  - Humidity, wind and sunlight = dried out surface & cracks

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Concrete Set Time - Lab Trials vs. Field Performance

- Lab trials reflect near perfect conditions and constant temperatures
- Field performance is impacted by ambient temperature and environmental conditions
- What could be different??

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Concrete Set Time - What to ask for or specify

- What to ask for or specify:
  - Ask for a place and finish plan
  - This will include:
    - Mix design and set time information
    - Anticipated weather
    - Field Conditions
    - Placement Method, etc.
  - Can be developed to maximize the opportunity for success.
  - Involve the Ready Mix supplier and the concrete finishers in a pre-pour meeting.

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Strength Gain for Opening Structures or Pavements

- Plan for success
  - How high and how early?
  - Verify anticipated weather
  - Verify anticipated pour timeframe
  - Select a mix that will work based on these inputs

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How critical is curing temperature?

- How can Maturity help?

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What is concrete maturity?

- Concrete maturity is:
  - a non-destructive method to determine how far concrete hydration has progressed.
  - This is determined through the relationship of in place concrete temperature and time, which determines strength gain.
- A maturity curve is developed in a lab according to ASTM C1074

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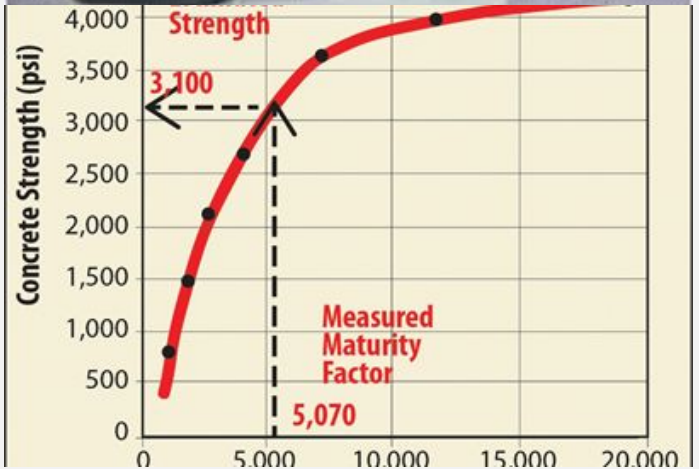
What is concrete maturity?

- Loggers are then installed in a field placement and can be monitored to determine strength gain progress
- The loggers provide a real time value that can be compared to the maturity curve in order to determine real time, in place strength



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Is your data accurate and dependable?

- The key to successfully placing high early concrete
  - Measure the strength accurately
  - Feel confident that your data is dependable

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Review

- Faster Set for Finishing = Accelerated
- Early Strength for loading = High Early
- Material and Environmental conditions can both dramatically change mix performance
- Plan ahead
- Communicate your needs

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Thank you for attending!

- Q/A Session

COLORADO READY MIXED CONCRETE ASSOCIATION

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